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# METHODOLOGY INVESTIGATION. A COMPARISON OF RELIABILITY TESTS FOR AVIONICS EQUIPMENT ONBOARD U. S. ARMY HELICOPTERS


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# METHODOLOGY INVESTIGATION
# FINAL REPORT
# A COMPARISON OF RELIABILITY TESTS FOR AVIONICS EQUIPMENT ONBOARD U. S. ARMY HELICOPTERS

BY
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APRIL 1975





SOUTHWEST RESEARCH INSTITUTE
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An investigation was conducted to determine which of several reliability tests provided a most realistic representation of field environments experienced by avionics equipment onboard US Army helicopters. Originally the program was scheduled to test a total of twenty-five AN/ARC-115 radios in groups of five, where each group was subjected to a different reliability test. Flight tests, bench tests, AGREE tests, Uniaxial vibration tests, and triaxial vibration tests were the selected environments in

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which the radios were to be operated under simulated conditions, functional checks performed as required, and any failures noted. Elements of White Sands Missile Range, New Mexico, the US Army Aviation Test Board, Ft. Rucker, Alabama, and Southwest Research Institute contributed to the program. Unfortunately the effort was terminated before completion because of a cutback in funding. As a result, only partial results were available from which only limited conclusions could be drawn.

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US ARMY ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

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## SECTION 1. BODY

### 1. BACKGROUND

The development of improved test procedures for demonstrating the reliability of avionics equipment onboard aircraft and other vehicles has been a continuing goal of the Test and Evaluation Command. As part of this program, several years ago Southwest Research Institute conducted a research effort which demonstrated that the validity of laboratory vibration tests in representing field environments could be greatly improved by the use of simultaneous multiaxis testing, rather than using uniaxial test procedures that were, and are for the most part, still in use. Details of that study are reported in Reference 1.

An immediate continuation of the above developments subsequently proceeded whereby SwRI, working in conjunction with two other U. S. Army organizations, could verify the practicality of the results by conducting several different types of reliability tests on a set of typical avionics specimens and comparing the results from these tests. The purpose of this report is to present the findings of this latter part of the overall effort. However, because of funding limitations and related changes in priorities within the overall TECOM research effort, this reliability test program was terminated before all results could be acquired. Therefore, of necessity, this report presents information which is incomplete as far as any conclusions about the comparative validity of the various reliability tests considered, but will be of extreme utility, should the program be again continued at a later date.

The contract identified above was initiated in order to allow SwRI to work directly with personnel at White Sands Missile Range (WSMR) and the U. S. Army Aviation Test Board, Ft. Rucker, Alabama (USAAVNTBD),

to determine the validity of laboratory tests for proving reliability of avionics equipment used onboard U.S. Army helicopters. The role of the USAAVNTBD has been to provide flight test and bench test support [Reference 2], while that of WSMR has been to provide laboratory test support [Reference 3]. Briefly, the responsibility of SwRI has been to provide technical consultation and recommendations for the conduct of the tests, assemble and analyze the resulting data, and summarize these efforts into a final report. Overall coordination of the effort was under the direction of the Aviation Material Test Directorate of the Test and Evaluation Command.

Originally, this program included flight and laboratory tests of multiple units of AN/ARC-115 radios and a "dummy" mechanical model radio which was designed at SwRI. The function of the latter device was to provide more detailed data for fatigue failure correlations. At the outset, emphasis was to be placed on tests of the prototype radios, and experimentation with the dummy was to be "piggy-backed" into these tests. The original schedule for tests of the AN/ARC-115 radios is given in Reference 4, and included efforts to be conducted through May 1975. However, for various reasons (some of which will be outlined later) the test program slipped schedule, although tests on the dummy radio were concluded since they were far less extensive.

Preliminary analyses of the fatigue data taken on the dummy radio proved to be particularly useful in comparing the fatigue potential of a given field vibrational environment with that of a corresponding laboratory test simulation. As a result, this part of the effort was transferred to a new contract, which included application of the method developed to truck and tracked vehicle environments as well. This latter effort has now been completed, and details of the results are presented in Reference 5. Thus, the information presented herein will be limited to that part of the program concerned with reliability testing of the prototype AN/ARC-115 radios.

As pointed out above, compilation, writing, and publication of this report is part of the contractual responsibility of Southwest Research Institute. However, the efforts of numerous personnel at other organizations were essential in the overall investigation. Further, many of the comments and ideas presented in this report are based on direct communication, both verbal and by correspondence, with those personnel. Some of the text is taken directly from notes they provided to the SwRI Project Manager. Therefore, at least a brief acknowledgement of the key personnel will be given near the end of the report.

## 2. OBJECTIVES

The objectives of this program are as follows:

a. Acquire twenty-five AN/ARC-115 radios to be used for various reliability tests.

b. Flight test five radios to 1200 hours each at USAAVNTBD. Acquire further vibration data as part of this series.

c. Bench test five radios to 1200 hours each at USAAVNTBD.

d. Conduct AGREE tests on five radios to 1200 hours each at WSMR.

e. Develop laboratory test specifications from flight vibration data.

f. Conduct laboratory uniaxial vibration tests on five radios to 1200 hours each at WSMR.

g. Conduct laboratory triaxial vibration tests on five radios to 1200 hours each at WSMR.

h. Analyze all resulting data to determine comparative validity of laboratory reliability tests.

## 3. DETAILS OF THE INVESTIGATION

### 3.1 INTRODUCTION

At the outset of this program it was recognized that the elements of the philosophy and methods of reliability testing outlined in Reference 6 and similar basic documents had to be incorporated into the investigation. However, it was further recognized that procedures outlined in that publication have the specific objective of providing reliability estimates for one set of samples for a given specimen. On the other hand, in the present program the objectives require the conduct of several different types of tests, and a comparison of the results to arrive at some deduction about the validity of the laboratory tests. The flight tests were to be representative of a typical field environment, and the candidate laboratory tests were selected as those deemed typical of current laboratory tests, or one which was most likely to improve on current laboratory methods. Obviously, the incorporation of a bench test would provide results which would determine if vibration had no influence on the specimen reliability. Thus, the ultimate objective was to determine which, if any, of the candidate

laboratory tests provided reliability results sufficiently similar to those of the field environment, so that it would form an acceptable alternate test procedure. Naturally, all the usual arguments for and advantages of laboratory testing over field testing (i.e., far less expense, more convenience, shorter time schedule, etc.) all dictated the desirability of carrying out the objectives of this program.

In view of the above stated objectives of this program, it was apparent that the selection of a set of test specimens having an already-established mean time between failure (MTBF) was desirable, in order to allow a reasonable estimate of the test durations that would be required. Again, the objective was not to confirm an existing MTBF for the specimen per se, but to acquire data on several types of tests whereby conclusions about the validity of the tests could be established.

Various other factors besides that stated above were considered in the selection of the AN/ARC-115 radio as the specimen with which this program was to be conducted. Most of these factors will not be elucidated in this report. However, suffice it to say that availability of specimens as well as compatibility with available test equipment was the most influential factor. Unfortunately, this specimen at the same time was known to have an MTBF of 1200 hours, which meant that rather lengthy test sessions would be necessary.

The format of this report will include a more or less chronological sequence for the work. However, it is intended to present a logical sequence in the development of the program philosophy, rather than a chronological order. Thus, we begin with a brief description of the radio specimen and some of the procedures necessary in its acquisition, and proceed to a description of each kind of reliability test. For those tests that were never completed, information will be presented which had developed up to the time of program termination. Finally, the necessarily limited conclusions and recommendations will be given.

## 3.2 DESCRIPTION OF SPECIMEN

### 3.2.1 Radio Details

A complete description of the AN/ARC-115 radio is given in Reference 7, from which several pages have been included in Appendix C of this report for convenience. For those readers not familiar with the physical shape of this specimen, a drawing of its general configuration is given in Figure 1. The radio face is approximately five inches high by six inches wide.

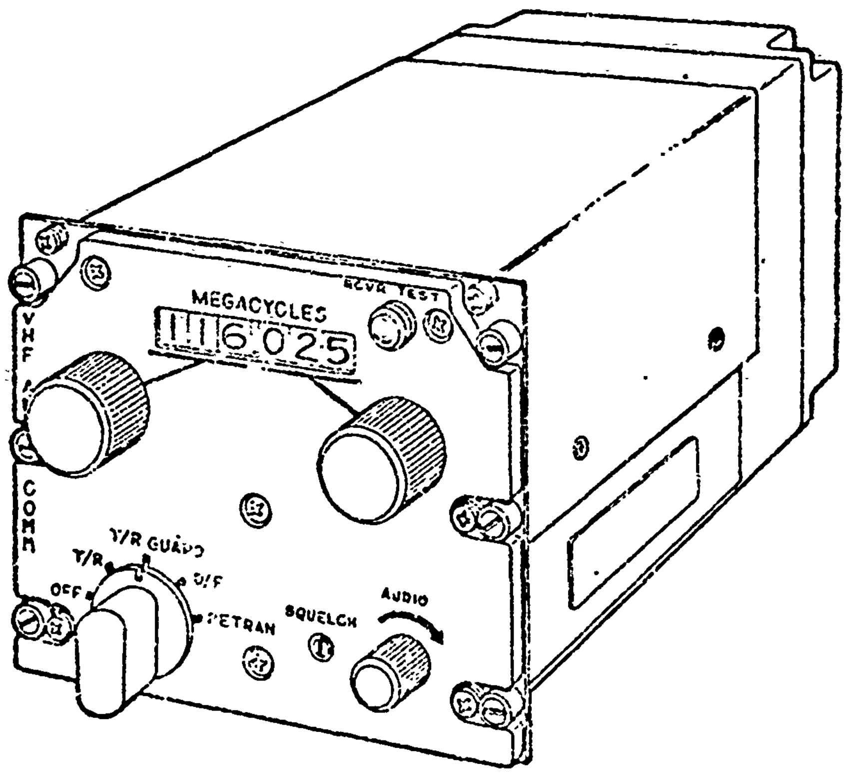



Figure 1. Radio Set AN/ARC-115

Some details of the radio characteristics can be obtained from Appendix C. However, here we will provide just enough description to indicate that it was chosen as a typical avionics item which includes state-of-the-art design. The AN/ARC-115 radio set is an airborne, very high frequency (vhf) amplitude modulated (am), radio receiving-transmitting set which contains a multichannel, electronically tunable main receiver and transmitter, a fixed-tuned guard receiver, and has a direction finding capability when used with external equipment. The radio set, when operated in conjunction with appropriate other equipment, is used for receiving and transmitting clearvoice communications. An additional capability for retransmission of clearvoice communications allows usage of the radio set as a relay link. Use of the direction finding capability of the radio set provides an enable signal to externally-located direction finding equipment. The radio set operates in conjunction with the external direction finding equipment to provide outputs to a heading indicator for a visual presentation of station direction.

### 3.2.2 Specimen Acquisition and Preliminary Arrangements

In preliminary meetings involving all project personnel, it was decided that five radio sets would be assigned as specimens for each of the planned reliability tests. Thus, twenty-five radios were required in total. As indicated in Reference 2, the USAAVNTBD was given responsibility for initial acquisition and checkout of the specimens. It was also requested that all radios be obtained from a common production lot. Initially, twenty-five test sample radios were requisitioned by the USAAVNTBD from Tobyhanna Army Depot. These radios were new stock manufactured by Sylvania Radio, Inc. Upon receipt, the radio sets were subjected to bench check inspection procedures outlined in Reference 7. Eight of the twenty-five sets failed to pass the acceptance test and were returned to Tobyhanna Depot in exchange for eight serviceable specimens. The USAAVNTBD was subsequently informed that Depot personnel tested the replacement radio sets to assure that they were serviceable, and in so doing found six more faulty sets. Ultimately, twenty-five serviceable radio sets were received at the USAAVNTBD.

Assignment of these radios by serial number to the various contemplated reliability tests was done according to Table 3.2-I. Subsequently, preparations proceeded for those test operations to be conducted by the USAAVNTB. Provision was made for a daily bench check of each specimen in each test phase, or environment, except for the helicopter flight tests. These checks, in accordance with Reference 7, had the purpose of detecting a degradation of performance which was not sufficient to activate the FAIL indicator on the control console. In the helicopter flight phase, the essence of this check occurs at the time of each flight. The pilot routinely logs equipment malfunctions or failures.

TABLE 3.2-1

ASSIGNMENT OF AN/ARC-115 RADIOS
TO VARIOUS RELIABILITY TESTS BY SERIAL NUMBERS

Helicopter Flight Tests

1716A
1849A
1873A
1899A
2050A

AGREE Tests

1581A
1851A
1932A
2027A
2123A

Bench Tests

1619A
1713A
2014A
2546A
2603A

Uniaxial Simulator Tests

1178A
1395A
1922A
1923A
2442A

Triaxial Simulator Tests

1690A
1744A
2215A
2412A
2434A

On the premise that the maintenance of the twenty-five test specimen radios would tax the in-house capability of the USAAVNTBD, a program was contracted with Northrop Worldwide Aircraft Service, Inc., Fort Rucker, Ala. The maintenance requirement was viewed as a potentially critical factor, in that each anticipated faulty set would have to be repaired and returned to service with minimum delay. The "buffer" usually provided by maintenance float would not exist; there is a very long delay in obtaining parts for this particular set, and the USAAVNTBD would not go into depot level maintenance, whereas the Northrop facility did. Thus, it was initially anticipated that volume of test specimen maintenance would exceed USAAVNTBD capabilities, and provision for this was made. Ultimately, however, the number of actual failures that occurred was not as large as anticipated, and all maintenance was handled in-house.

Preparations for tests of the AN/ARC-115 radios were initiated at the USAAVNTBD in November 1972. This included formal actions of commitment, requisition of some equipment, purchase of some, and long-term borrowing of others. A major action included the design of appropriate wiring harness for the radio set (simulating aircraft system wiring), and an automated control scheme to turn sets ON and OFF, key the transmitters periodically, to monitor receiver and transmitter outputs, and to record the operating time for each specimen. These requisition procedures included preparations for other reliability tests to be described hereafter in other sections, as well as the flight test phases.

## 3.3 HELICOPTER FLIGHT TESTS

### 3.3.1 Reliability Tests

Development of a suitable flight plan was an immediate requirement for the flight tests. A typical operational flight plan was developed which corresponded with other test operations in progress at the USAAVNTBD. This typical plan, which encompasses a 108-minute flight, is given in Table 3.3-I. Test procedures were designed to provide repeated flights of the radios in various helicopters in order to accumulate up to 1200 hours on each radio set.

Two radio specimens were installed in OH-6 Helicopters, and three in OH-58 Helicopters, one set per helicopter. Flight tests were conducted in day-to-day operations at Fort Rucker, Alabama, and vicinity. The test specimens were not controlled in any particular manner; rather, they were used as the communication radio for the helicopters. The radio set was turned on throughout a given mission. The receiver was in continuous operation, and the transmitter was activated as required in the operation of the helicopter. Use of the above indicated helicopters required the installation of a Selected Lightweight Avionics Equipment (SLAI) package. Use of this configuration created some unanticipated problems, which will now be described.

## TABLE 3.3-I

## TYPICAL PLAN FOR HELICOPTER FLIGHT TEST OF AN/ARC-115 RADIOS

| Maneuver | Minutes | |
|---|---|---|
| | Duration | Total Time |
| Zero Signal | 2 | 2 |
| Cal 2G 0-peak | 0.2 | 2.2 |
| Helicopter Idle, on Ground | 2 | 2 |
| Lift Off and Hover | 5 | 7 |
| Take Off and Climb 500 ft/min | 2 | 9 |
| Level Flight Maximum Permissible Speed | 8 | 17 |
| Left Turn 90° Continue Level Flight | 5 | 22 |
| Right Turn 90° Continue Level Flight | 5 | 27 |
| Slow to Minimum Cruise Speed | 8 | 35 |
| Descent at 500 ft/min | 1 | 36 |
| Straight and Level Minimum Cruise Speed | 5 | 41 |
| Accelerate to Maximum Speed | 8 | 49 |
| Normal Cruise | 10 | 59 |
| Accelerate to Maximum Speed | 4 | 63 |
| Normal Cruise | 15 | 78 |
| Accelerate to Maximum Speed | 5 | 83 |
| Climb at 500 ft/min | 2 | 85 |
| Normal Cruise | 10 | 95 |
| Descent for Landing | 3 | 98 |
| Hover Flight | 5 | 103 |
| Hover | 1 | 104 |
| Set Down and Engine Shut Down | 1 | 105 |
| Zero Signal | 3 | 108 |

The electronic configuration of Army aircraft includes two command-type radio communication sets: one UHF set and one VHF set. In the CONUS, Army aviators are accustomed to using the UHF set primarily, if not exclusively, for command-type requirements. It was expected that an orientation of participating aviators would be essential to get full use of the VHF set in this progra· ı, and it was provided. However, the response was less than required to assure validity of test data. As an extreme measure to assure use of the test specimens, the UHF set was removed from each testbed. This action by the Test Program Manager resulted in surprising protest from several aviators. Actually, the VHF-only configuration is not new, not altogether unique, certainly not without extensive precedent.

The objection by some (usually the younger) aviators to operation without the UHF set produced a due number of complaints about the VHF test sample performance. These complaints of inadequate performance were investigated with the findings that, in fact, the VHF set performance (as would be apparent to an aviator in the cockpit) was not comparable to that of the UHF set, to which the aviator was accustomed in the same helicopter. While some of the removed UHF sets had had 20 watt transmitters, vs 10 watts of the VHF test samples (thus explaining part of the performance differential), the one common factor responsible was the poor location of the built-in VHF antenna (extreme aft end of tail boom). The UHF antenna location on the undersurface of the fuselage is decidedly better. New VHF antennas were procured for the five testbeds and installed at the position formerly used for UHF antennas, with the result that there were no more complaints of poor performance.

These flight tests began on March 14, 1973, and were terminated incomplete on October 7, 1974. Final results, including total numbers of hours logged as well as information on failures experienced in this and other reliability tests, will be given in a later section.

### 3.3.2 Special Instrumented Flight Tests

In order to obtain appropriate vibration data to be used for later development of specifications for the laboratory simulation reliability tests (uniaxial and triaxial), it was decided to conduct a special flight series whereby vibrations at the radio location could be recorded. At the same time, similar data were to be acquired for a "dummy" radio which was to be used in a later SwRI program (Reference 5). These tests were conducted in April 1973.

Figure 2 shows the location of the dummy radio in the usual slot for the AN/ARC-115 radio in the instrument panel of an OH-58 helicopter. Unfortunately, a corresponding photograph with the actual radio in the same

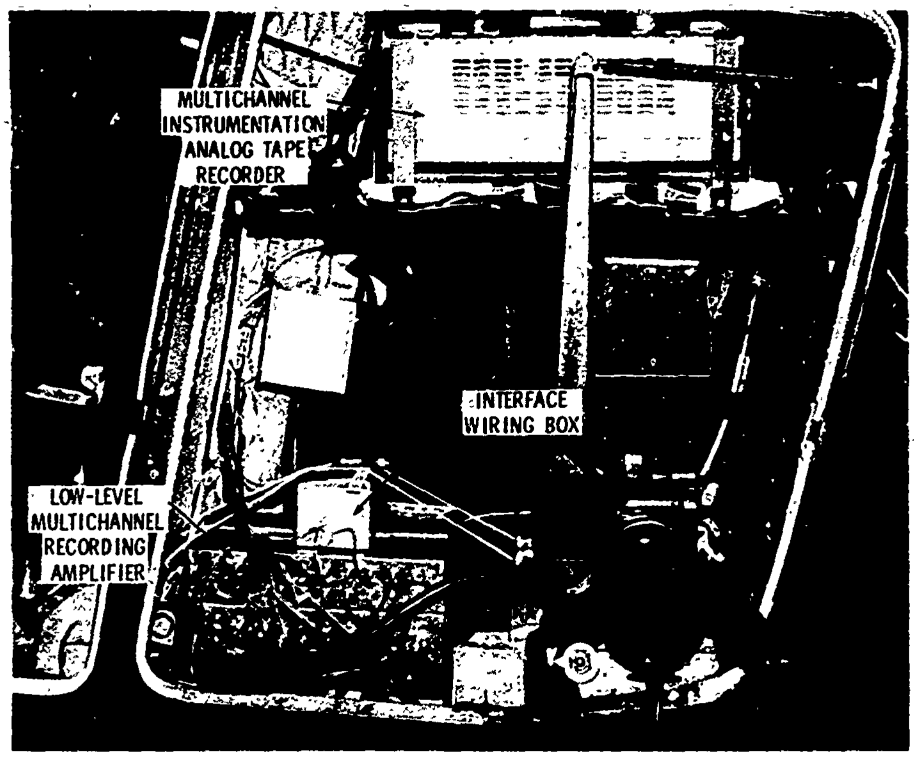



Figure 2. Location of AN/ARC-115
Radio on OH-58 Helicopter Instrument Panel
(Only Dummy Radio is Shown)

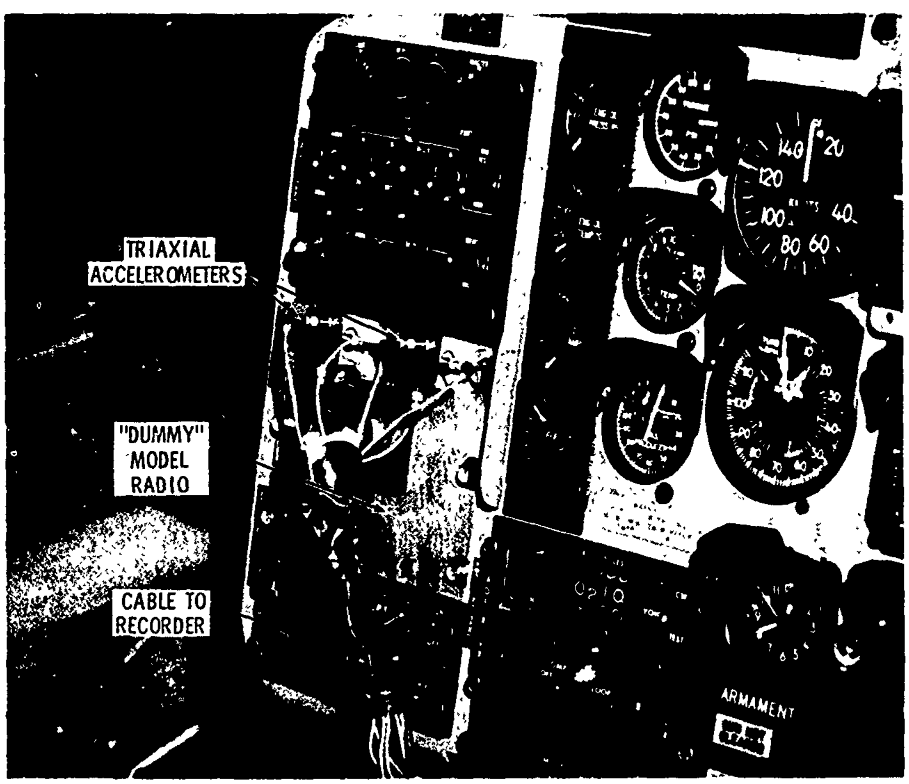



Figure 3. Data Recording Equipment
For OH-58 Helicopter Tests

location was inadvertently not taken. However, the radios were instrumented similarly with two triaxial accelerometers mounted each on one upper corner of the specimen. Additional cables shown in Figure 1 were peculiar to the dummy radio, and will not be discussed further here. Vibration data along with the pilot's voice description of the flight were recorded on an analog instrumentation tape system which is shown installed in the aircraft in Figure 3.

Two different missions were flown with the instrumented radios. A composite flight plan which was developed for each of these missions is given in Tables 3.3-II and 3.3-III. The first mission was basically similar to those used for the flight reliability tests (Table 3.3-I), although it was shorter in time duration. The second mission included gun run maneuvers and firing of the XM-27E1 7.62 mm Gun System. Subsequent to these tests, the tape recorded data were transmitted to SwRI for development into test specifications, as will be described in a later section.

## 3.4 BENCH TESTS

Reliability tests of five radio units operated automatically in a benign environment under bench test conditions were included in order to determine whether failure rates under these conditions were significantly different from all other test environments that included vibration. These tests were conducted in the Avionics Maintenance Shop of the USAAVNTBD. A photograph of the test arrangement is shown in Figure 4. The test was designed so that the specimen radios were electrically energized, actuated, and monitored in a sequence that simulated the flight test procedures. Functional test of the radios was then based on procedures given in Reference 7. A sample set of a check-off list for the bench tests is given in Appendix C. These tests began on March 29, 1974, and were terminated incomplete on October 11, 1974.

A brief description of the purpose of the various parts of the apparatus can be conveniently given by referring to Figure 4. The frequency counter is used typically to measure transmitter frequency in bench tests. The transfer oscillator is used in conjunction with the frequency counter. RF watt-meters measure transmitter power output continuously during specimen transmit time. The control console, as the name implies, contains interface wiring for power and control to five test specimens, monitor receiver outputs, record specimen ON time, etc. This device was designed and fabricated at USAAVNTBD specifically for this program. Finally, the signal generator supplies a continuous "transmitted" signal to each of the five test specimens. This same group of hardware was used for the other laboratory reliability tests, except, of course, for the five radio specimens.

TABLE 3.3-II

OPERATIONAL FLIGHT PLAN FOR OH-58 HELICOPTER
SPECIAL INSTRUMENTED TESTS WITHOUT GUNFIRE

| Time Min:Sec | Event |
|---|---|
| 0 | Start Data |
| 0:19 | Calibrate |
| 0:45 | On Ground Idle |
| 2:21 | Lift Off and Hover |
| 3:18 | Take Off and Climb, 500 ft/min |
| 4:42 | Level Max Speed, 105-110 KTS |
| 8:38 | 90° Left Turn Next |
| 8:51 | Start 90° Left Turn |
| 8:58 | Level Flight |
| 10:34 | Start 90° Right Turn |
| 10:59 | Level Flight |
| 12:03 | Right Turn |
| 12:41 | Decelerate to Min Cruise |
| 14:41 | Start Descent 500 ft/min |
| 15:47 | Accelerate to Max Speed |
| 17:39 | Start Gun Run |
| 17:44 | Dive |
| 18:08 | Enter Gun Run Descent |
| 18:11 | Tape Off and On |
| 18:30 | Climb |
| 19:28 | Level Max Speed |
| 21:06 | Enter Gun Run |
| 21:19 | Dive |
| 21:30 | Right Turn |
| 21:38 | Still Dive |
| 21:46 | Left Turn, Sharp Turn |
| 21:55 | Level |
| 21:58 | Climb |
| 22:09 | Climb for 1 Min |
| 23:07 | Start Max Speed |
| 23:16 | Start Sharp Right Turn |
| 23:39 | Straight and Level Max Speed |
| 25:09 | Decelerate to Normal Cruise |
| 26:49 | Sharp Right Turn |
| 26:57 | Climb 500 ft/min Next |
| 27:11 | Start Climb |
| 28:17 | Level Normal Cruise |
| 29:43 | Sharp Right Turn |
| 29:51 | Rapid Descent for Gun Run |
| 30:24 | Going into Gun Run |
| 31:26 | Recorder Off and On |
| 31:55 | Start Descent |
| 32:59 | Start Hover |
| 33:43 | Start 1 Min Hover Flight |
| 35:38 | Touch Down Idle |
| 35:54 | Slowing Down |
| 36:28 | Data Off |

TABLE 3.3-III

OPERATIONAL FLIGHT PLAN FOR OH-58 HELICOPTER SPECIAL INSTRUMENTED TESTS WITH GUNFIRE

| Time Min:Sec | Event | Time Min:Sec | Event |
|---|---|---|---|
| 0 | Start Data | 15:07 | Descending |
| 0:21 | Start Calibration | 15:09 | Straight |
| 0:53 | Calibration Off | 15:19 | Firing |
| 1:06 | Engine On Warm Up | 15:26 | Firing |
| 2:52 | Engine Rev Up | 15:34 | Firing |
| 3:27 | Lift Off and Start Hover | 15:47 | Left Turn |
| 4:15 | Forward | 16:52 | Banking Left |
| 4:26 | Climb 500 ft/min | 17:21 | Start Gun Run |
| 5:08 | Level | 17:38 | Firing |
| 5:27 | Left Turn | 17:47 | Firing |
| 5:41 | End Left Turn | 17:58 | Left Turn |
| 5:47 | Level | 19:22 | Left Turn |
| 5:51 | Climbing | 19:26 | Start Gun Run |
| 6:54 | Left Turn | 19:39 | Firing |
| 7:20 | Descending | 19:45 | Firing Short Burst |
| 7:25 | Start Hover | 19:51 | Firing |
| 7:46 | Stopped Idle | 19:58 | Firing |
| 9:48 | Lift Off Start Hover | 20:09 | Left Turn |
| 9:55 | Take Off and Climb | 21:03 | Start Right Turn |
| 10:42 | Helicopter Moving | 21:07 | Banking Right |
| | Forward.... | 21:26 | Level |
| 12:13 | Tape Stop | 21:45 | Left Turn |
| 12:28 | Lift Off Start Climb | 22:00 | Stop Turn Start Descent |
| 12:55 | Firing | 22:11 | Descending 500 ft/min |
| 13:00 | Firing | 23:02 | Left Turn |
| 13:10 | Firing | 23:22 | Stop Turn |
| 13:26 | Left Turn | 23:28 | Max Speed |
| 14:04 | ---- | 24:20 | Left Turn Descending |
| 14:36 | Left Turn | 25:02 | Approach to Land |
| 14:53 | Climbing | 25:20 | Touch Down |
| 15:02 | Complete Turn Start | 25:25 | Idle |
| | Gun Run | 25:53 | Data Off |

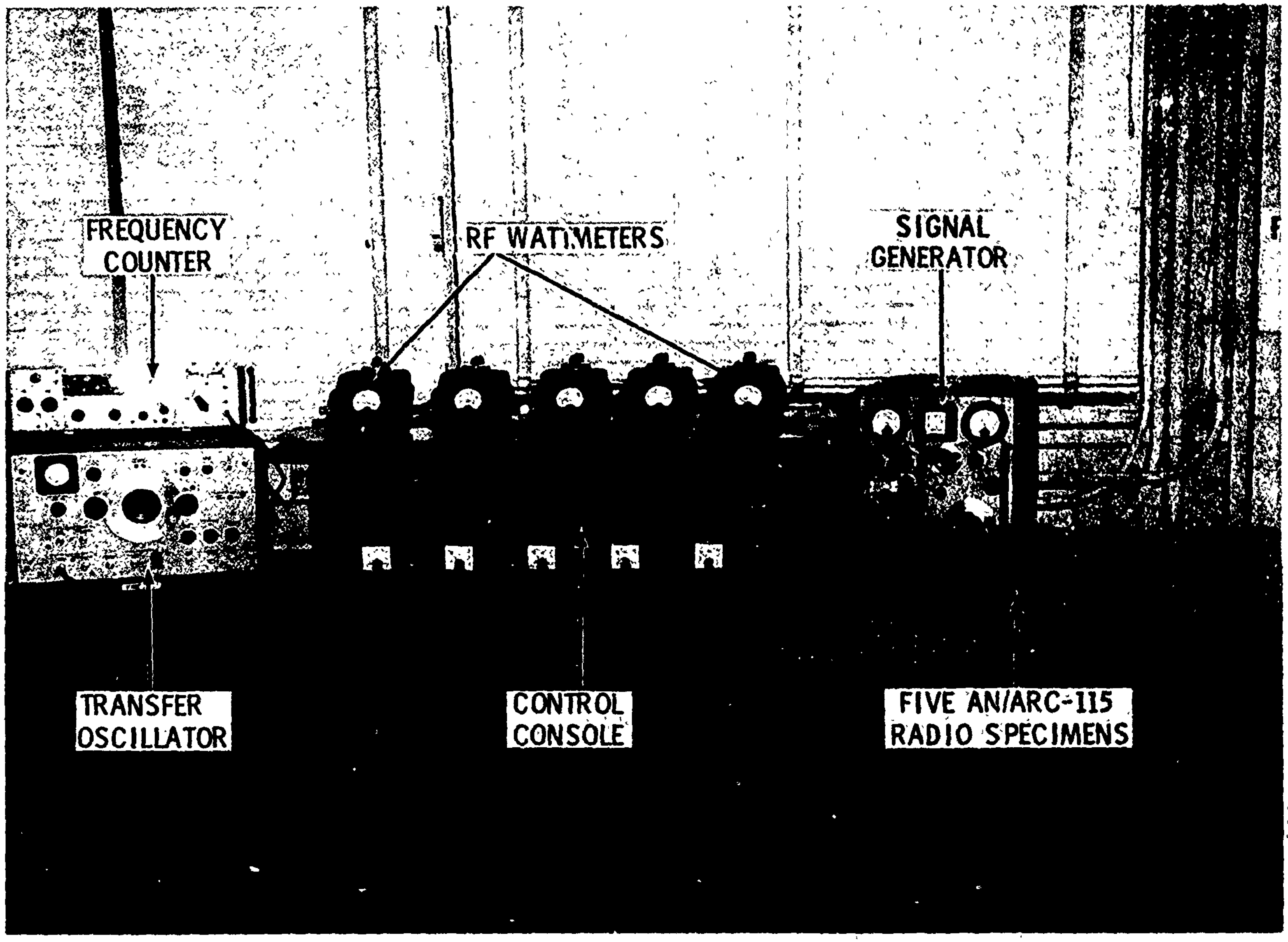



Figure 4. Apparatus For Bench Test of AN/ARC-115 Radios

## 3.5 AGREE TESTS

Temperature and vibration cycle tests according to Reference 6 are generally referred to as AGREE tests. This type of laboratory simulation was initiated on five AN/ARC-115 radio specimens at WSMR, New Mexico, on October 16, 1973. A photograph of part of the apparatus used for these tests is shown in Figure 5. The five radios were mounted in a fixture which rested on a vibration slip table. Vibration was imparted to the fixture by means of an electric motor driven cam mechanism. Operation of the motor was controlled by a timer. The heating and cooling autoclave is not shown in the photograph, but was mounted over the slip table. Automatic controlled heating and cooling were provided by this device.

One cycle of the general procedure for the test is given in Figure 6, while some additional details are given in Appendix C. This procedure is based on Test Level E of Reference 6. However, the vibrational frequency of 13 Hz is somewhat below the lower limit of 20 Hz given in the specification. The lower frequency was considered more appropriate since it is near the fundamental blade passage frequency on many helicopters. Thus, it is the primary excitation frequency on those aircraft. The electrical functional procedures conducted during the radio ON time were similar to those described for the bench tests.

The above-described tests continued on a five-day a week basis. WSMR personnel were responsible for the mechanical operation of the system, while USAAVNTBD personnel on TDY performed the electrical functional checks. These tests were terminated incomplete on April 25, 1974.

## 3.6 VIBRATION DATA DEVELOPMENT

Both the uniaxial and three-dimensional tests required the development of a particular test specification or procedure to cover the vibration part of the reliability tests. It was decided early in the program that these tests would be based on the use of tape recorded flight data as input signals to the shaker systems. Acquisition of such data has already been described in Section 3.3.2. However, it was necessary to analyze and edit the data to be suitable for use in a test specification.

A description of the maneuvers and activities of the flight test vibration data has been presented in Tables 3.3-II and 3.3-III. The raw analog data which result from such tests typically include numerous gaps within which data recordings were started and stopped, and switching transients necessarily are also recorded as part of the resulting analog signals. Such transients are not part of the desired data, and can cause severe shaker overloading problems. Therefore, it becomes appropriate to produce an edited tape to be used as the test input signal.

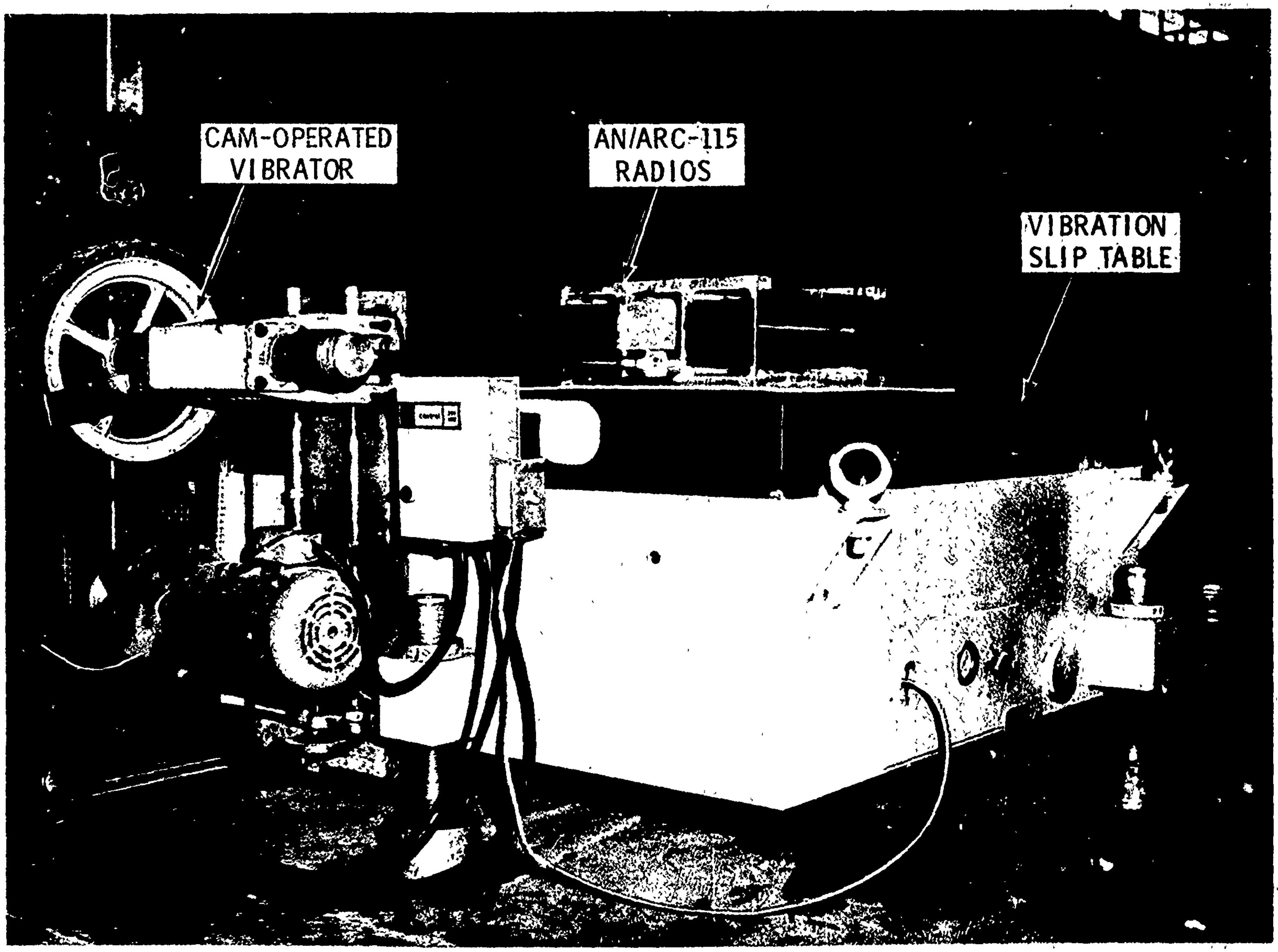
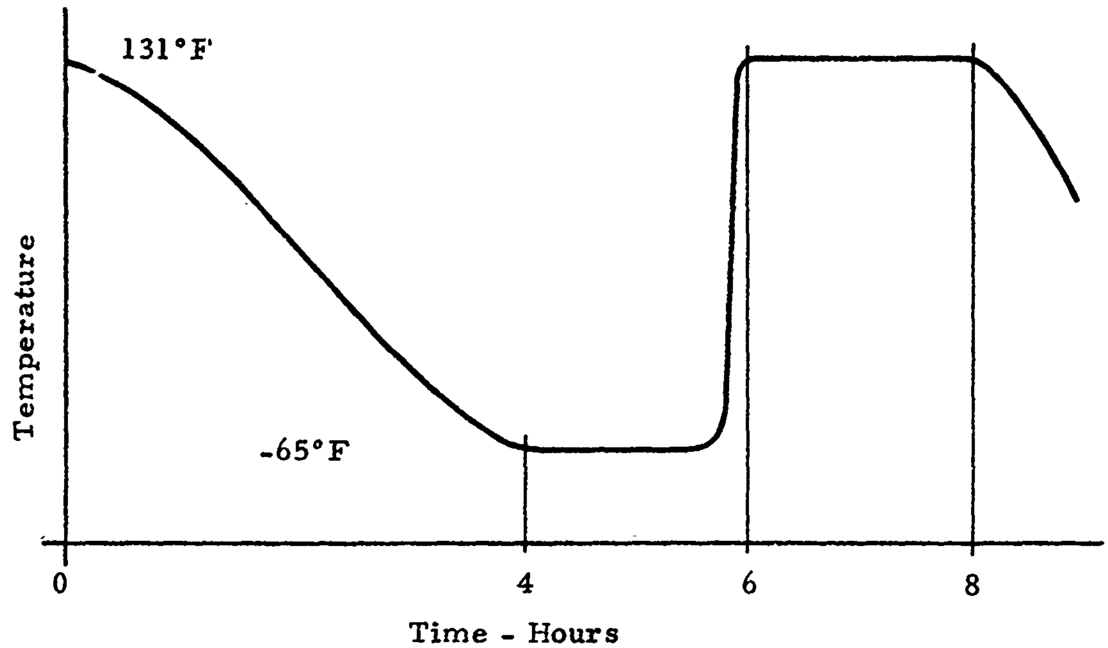



Figure 5. AGREE Test Apparatus (Without Heating Autoclave Installed)




| Time (Hours) | Activity |
|---|---|
| 0 | Temperature at 131°F. Radio sets switched to OFF position. Vibration switched off. Start temperature decrease. |
| 4 | Temperature at -65°F and hold. Turn radio sets to ON position. Cycle vibration for 5 minutes each 1/2-hour at 13 Hz and 2.2g sine amplitude. Increase temperature near end of period. |
| 6 | Hold temperature at 131°F Continue radio ON and vibration. |
| 8 | Cycle complete. Repeat process. |

Figure 6. Summary of AGREE Test Procedure

Various methods of performing the editing process were considered, and included both analog and digital computational techniques. However, a purely analog method was finally selected and performed at SwRI. A composite tape representing a 105-minute mission corresponding to that described in Table 3.3-I was produced. This was accomplished by splicing together the signals from the various maneuvers so that the proper time durations and order were developed. The splicing process included playback and careful noting of the data positions on the tape on one recorder. Then, repeated playback of this tape was synchronized with recording of the data on a second tape recorder. Note that no physical splicing of the tape was included, so that typical transients associated with splices in analog tape were avoided. Thus, a continuous 105-minute composite mission tape resulted, which included x, y, and z-axis acceleration signals from both accelerometers, and voice logging of all maneuvers. This composite tape was shipped to WSMR upon completion of the editing process.

## 3.7 UNIAXIAL VIBRATION TESTS

It was intended that uniaxial vibration tests of five AN/ARC-115 radios would be conducted at WSMR, New Mexico, and again, electrical functional operations and checks similar to the bench tests would be included. Basically, an operation similar to the flight tests was desired, except, of course, the vibration would be provided by the analog-taped signals via the laboratory shaker, rather than directly from the aircraft. Thus, multiple simulated missions were anticipated. These tests were very near initiation, although never actually started, when the program was terminated. Therefore, herein we will provide only some further brief description of the system which was designed for implementing the tests.

A photograph of the apparatus intended for use in the uniaxial tests is shown in Figure 7. Five AN/ARC-115 radios were mounted in a fixture which was in turn mounted to a horizontal vibration table. The vibration table was suspended between two electrodynamic shakers which were operated in a push-pull configuration. By analysis of the radio internal construction, it was decided that vibration perpendicular to the radio face would have the most severe effect on the radios (this direction is perpendicular to the internal component cards). Likewise, since the test was only uniaxial, and the original vibration data were triaxial, it was decided to use as the excitation signal that particular channel of acceleration data which was most severe over the overall mission sequence. Obviously, achieving conservatism was the test objective.

Equalization of the electrodynamic shakers was produced to a close tolerance throughout a 10 to 500 Hz frequency range by means of analog equalization filters. As a result, exact duplication of vibration time histories

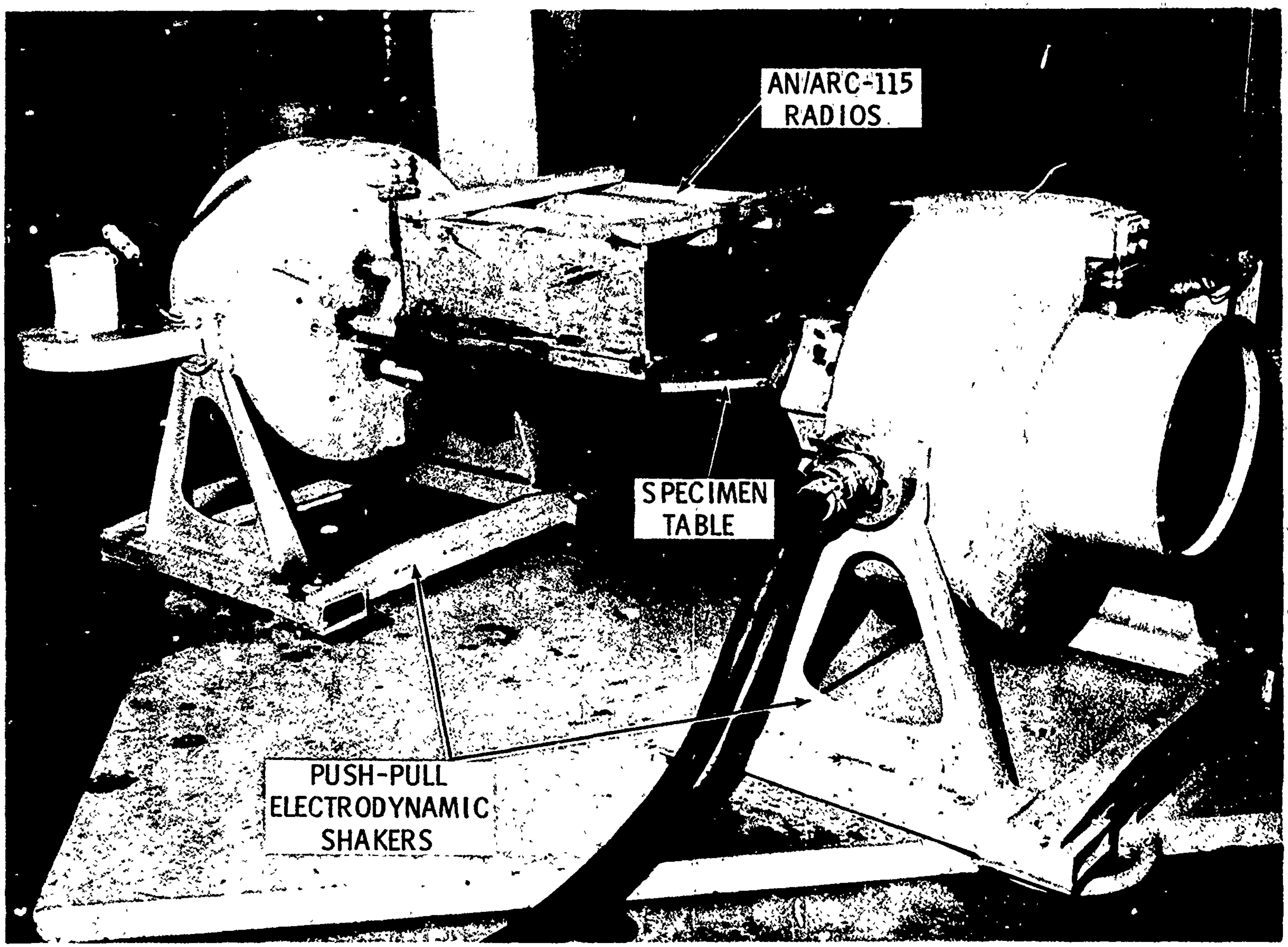



Figure 7. Apparatus For Uniaxial Vibration Tests

was not considered essential, but rather, reasonable duplication of acceleration power spectral density of the table motion with that of the taped signal was selected as the test criterion. This was verified by analysis of corresponding parts of each of the data signals. This system was ready for operation at the time of program termination.

## 3.8 THREE-DIMENSIONAL VIBRATION TESTS

This type of laboratory test was to use a procedure similar to the uniaxial tests, except that analog taped vibration signals for each of the x, y, and z-axes were to drive a shaker system simultaneously each along corresponding mutually perpendicular axes. The shaker and control system for this test was not operational at the time of program termination. It necessarily is a more complex system. Only a few comments will be provided here, which are based on the several concepts of the tests that had already been developed.

A triaxial shaker facility was under construction at WSMR, New Mexico, which could allow simultaneous translational excitation along three mutually-perpendicular axes. This facility is powered by three electrodynamic shakers and includes a table of special design. No further information on this facility will be given in this report, as it is not yet complete and some modifications of the system were still in progress. It was anticipated that digital control of this system was to be provided for each axis independently. That is, digital automatic equalization would be employed. The criterion for the specification would be for the time-averaged power spectral densities of table acceleration along a given axis to be made to match to close tolerance the corresponding power spectral density of the analog taped vibration signal at corresponding points in the simulated mission. Electrical function of the radios would also simulate the corresponding maneuvers that were being experienced, so that again, a close simulation of the flight experience was achieved. Multiple tests would represent multiple missions. It was anticipated that this form of laboratory test would provide the best simulation of the true flight environment.

# 4. SUMMARY OF RESULTS AND CONCLUSIONS

As pointed out in the previous sections, not one of the five different reliability test programs was completed, and data were acquired on only the first three. The results of the incomplete tests at the time of program termination are presented in Table 4.0-I.

It is interesting to note that for the three different tests on which data were acquired, the 13 total failures occurred over a span of operational time from 5 hours (on a specimen in the AGREE test) to 902 hours (on a specimen

TABLE 4.0-I

FAILURE RESULTS FOR RELIABILITY TESTS OF AN/ARC-115 RADIOS

| Type of Test | Radio Serial No. | No. of Hours Tested | No. of Failures | Hours at Failure | Type of Failure | |
|---|---|---|---|---|---|---|
| | | *See Note | | | | |
| Flight | 1849A | 499.6 | 1 | 105.4 | A1A2A9 | Squelch Control |
| Flight | 1716A | 260.3 | 1 | 196.9 | A2A3 | Modulator Adjust |
| Flight | 1873A | 531.3 | 2 | 198.4 | A1A1 | Frequency Selector |
| | | | | 234.3 | A2A4 | Power Amplifier |
| Flight | 1899A | 1098.3 | 1 | 258.3 | A1A3A3 | CR-2 Noise Generator |
| Flight | 2050A | 1253.6 | 1 | 448.3 | A2A2 | Q6 in Power Supply |
| Total | | 3964 | | | Failure Rate: 660 Hr/Failure | |
| | | *See Note | | | | |
| Bench | 2546A | 1373.7 | 0 | -- | -- | |
| Bench | 1713A | 807.2 | 2 | 96.5 | A1A3 RF Amplifier, A2A2 Power Supply | |
| | | | | 187.8 | A1A2 | Amplifier |
| Bench | 1619A | 955.7 | 2 | 195.8 | A1A2A9 | Squelch Control |
| | | | | 901.7 | A2A2 | Power Supply |
| Bench | 2014A | 802.0 | 1 | 652.1 | A1A2A9 | Squelch Control |
| Bench | 2603A | 842.9 | 0 | -- | -- | |
| Total | | 5254 | | | Failure Rate: 1050 Hr/Failure | |
| AGREE | 1581A | 1214.0 | 0 | -- | -- | |
| AGREE | 1932A | 1056.0 | 1 | 652.0 | A2A2 | Q7 Voltage Regulator |
| AGREE | 2123A | 6.5 | 1 | 5.0 | A2A2 | Q10 & CR8 Power Supply |
| AGREE | 2027A | 1200.0 | 0 | -- | -- | |
| AGREE | 1851A | 1203.0 | 0 | -- | -- | |
| Total | | 4679.5 | | | Failure Rate: 2340 Hr/Failure | |

*Number of hours tested for each individual radio were maintained only through 16 September 1974. Additional tests were run in the Flight and Bench environments up to October 1974. However, only total numbers of hours were recorded for this period. Also, no failures occurred in this additional testing.

on the bench test). Several specimens experienced multiple failures, and there appears to be some correlation in the type of failures. The squelch control on card A1A2A9 and the power supply section appear to be most failure prone. Note also that the first failure (at 5 hours) and the last failure (at 902 hours) occurred in what were perhaps the most severe and least severe environments respectively. These both occurred in the power supply, although the faulty components were different in each case. It is interesting to recall, that according to previous field experience, the AN/ARC-115 radio has suffered a tendency toward failure in the power supply section.

Since no data were obtained from the laboratory simulations of the flight vibration environments, no comparisons can be drawn between the simulated and field environments. However, it can be noted that the average rate of failures in the flight tests was 660 hours per failure; for the bench tests it was 1050 hours per failure; and for the AGREE tests it was 2340 hours per failure. It must be recognized that these data are incomplete, but one is tempted to conclude from this information that the results from the bench and flight tests are comparable, while those for the AGREE tests are considerably different. Apparently the temperature cycling provided a slowing of the aging process that was not overcome by the presence of the vibration in that test. Also, the bench test results appear to be in the ball park of the estimated 1200 MTBF for the radio available at the start of the program. This probably indicates that the previous figure was obtained under similar test conditions. If this is true, the flight-tests indicate a rather significant deterioration in MTBF due to the flight vibrational environment.

Relative cost and time requirements for the various tests are another important means of comparison. Some estimates of these parameters are included in Table 4.0-II. The least expensive program (uniaxial) appears as unit cost with the others as multiples of it. It should be emphasized that these figures are only estimates, with varying degrees of approximation associated with them. Obviously, those figures for tests in which a relatively large number of hours were accumulated are more accurate than those for which no tests have been run at all. Thus, the numbers should be used simply as an overall guide, rather than an accurate assessment.

Relative costs in Table 4.0-II include estimates for overhead and assume a dedicated program in each case. Only the flight tests could readily be piggybacked onto some other program to reduce costs. In such a case, its relative cost might drop to as little as 10.0, depending on the amount of cooperative program that could be developed. In any case, it is obvious that the cost of flight tests is several times greater than the other

test methods. Not only is flight testing inherently more expensive, but only one radio specimen can readily be tested in a single aircraft, while for the other methods, all five radios can conveniently be tested simultaneously. Whether or not the numbers are sufficiently accurate to say which of the laboratory methods is least expensive is debatable.

TABLE 4.0-II

ESTIMATED RELATIVE COST AND TIME REQUIREMENTS

| Type of Test | Relative Cost | Calendar Time (Mos.) |
|---|---|---|
| Uniaxial | 1.0 | 6 |
| Bench | 1.3 | 6 |
| AGREE | 2.5 | 6 |
| 3-D | 3.0 | 14 |
| Flight | 18.8 | 14 |

It is recognized that the above comments can only be made on a qualitative basis because of the incomplete test results. Had complete information been available, a more meaningful analysis of the significance of the results could have been performed on a statistical basis.

## 5. RECOMMENDATIONS

Since this program was terminated before completion, there can be only one recommendation which results from it. That is, at the earliest possible date, the program should be reinstated whereby the original program objectives can be achieved. In particular, the influence of the vibration environment on the reliability of the radio has not been established, and further, no conclusions can be drawn whether the laboratory vibration environments form a reasonable simulation of the field environment. It is especially pertinent to determine whether three-axis testing will produce any significantly better simulation than the other form of tests, since it is substantially more expensive to implement than some of the others. However, it is, of course, still far less expensive than flight testing. Reinstatement and completion of the program will still allow answers to these questions.

## 6. ACKNOWLEDGMENTS

As pointed out in the introduction to this report, a number of personnel from several different organizations contributed significantly to the ideas and efforts necessary to conduct this program, and to the compilation of information and data necessary for writing the report. Overall program direction was provided by Mr. Louis F. Storm of Aberdeen Proving Ground. The Test Program Manager at USAAVNTBD was Mr. John H. Gray, who also provided numerous program notes. He was assisted by Mr. Russell E. Sharp, Project Officer, and S/SGT James E. Yonick and S/SGT Alan L. Smith as Assistant Project Officers. Activities at WSMR came under the direct supervision of Mr. Fred M. Edgington and Mr. David T. Boley. Finally, valuable efforts at data acquisition and analysis were provided by Mr. Guido E. Ransleben and Mr. Dennis C. Scheidt of SwRI.

# SECTION 2. APPENDICES

## APPENDIX A - CORRESPONDENCE

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## APPENDIX B - REFERENCES


1. Kana, D. D., Huzar, S., and Bessey, R. L., "Simulation of the Vibrational Environment Affecting Reliability of Avionics Equipment Onboard U.S. Army Helicopters," Final Report Contract DAAD05-70-G-0271, Southwest Research Institute, May 1971.

2. Letter dated 8 November 1972, To: President, U. S. Army Aviation Test Board, STEBG-MO, Ft. Rucker, Alabama, From: Aviation Material Test Directorate, Headquarters, U. S. Army Test and Evaluation Command.

3. Letter dated 8 January 1973, To: Commander, White Sands Missile Range, STEWS-TE, WSMR, New Mexico, From: Aviation Material Test Directorate, Headquarters, U. S. Army Test and Evaluation Command.

4. Letter dated 23 October 1972, To: Commander, U. S. Army Electronics Command, AMSEL-ES, Ft. Monmouth, New Jersey, From: Aviation Material Test Directorate, Headquarters, U. S. Army Test and Evaluation Command.

5. Kana, D. D., and Scheidt, D. C., "Fatigue Damage Equivalence of Field and Simulated Vibrational Environments," Final Report Contract DAAD05-74-C-0729, Southwest Research Institute, November 1974.

6. "Reliability Tests: Exponential Distribution," MIL-STD-781B, Department of Defense, 15 November 1967.

7. "Organizational Maintenance Manual Including Repair Parts and Special Tool List for Radio AN/ARC-115," TM 11-5821-26-20, Department of Defense, July 1968.

# APPENDIX C-1



# EXCERPT FROM TM11-5821-260-20

## CHAPTER 1

## INTRODUCTION

### Section I. GENERAL

**1-1. Scope**

*a.* This manual describes Radio Set AN/ARC-115 (fig. 1-1), and provides instructions for installation, operation, and organizational maintenance. It includes instructions for operation under usual conditions, cleaning and inspection of the equipment, and replacement of parts available to the organizational repairman.

*b.* Appendixes B, ~~E~~ and C ~~F~~ are current as of 1 May 1970.

**1-2. Indexes of Equipment Publications**

*a. DA Pam 310-4.* Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

*b. DA Pam 310-7.* Refer to DA Pam 310-7 to determine whether there are modification work orders (MWO's) pertaining to the equipment.

c. TM11-5821-260-20P. Refer to the Organization Maintenance Repair Parts and Special Tools List for Radio Set AN/ARC-115, TM11-5821-260-20P, for the part number, federal stock number, and other pertinent information required for the repair of the radio set. Also included are exploded views of the radio set which may facilitate repair and replacement of parts.

**1-3. Forms and Records**

*a. Reports of Maintenance and Unsatisfactory Equipment.* Use equipment forms and records in accordance with instructions in TM 38-750.

*b. Report of Packaging and Handling Deficiencies.* Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58 (Army), NAVSUP Pub 378 (Navy), AFR 71-4 (Air Force), and MCO P4030.29 (Marine Corps).

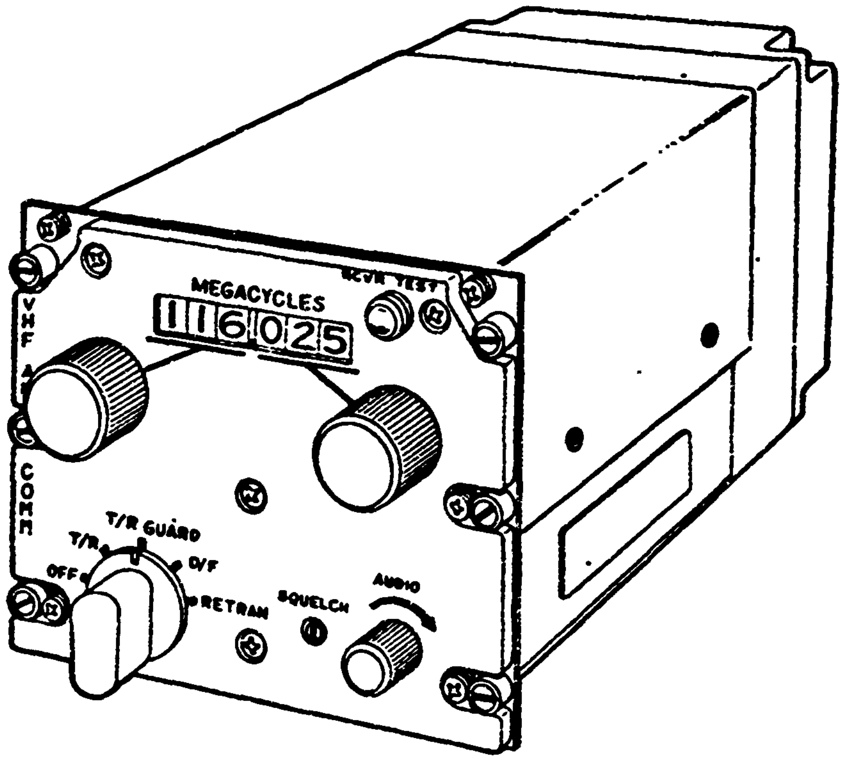
*c. Discrepancy in Shipment Report (DISREP) (SF 361).* Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38 (Army), NAVSUP Pub 459 (Navy), AFM 75-34 (Air Force), and MCO P4610.19 (Marine Corps).

*d. Report of Equipment Publication Improvements.* Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded direct to Commanding General, U.S. Army Electronics Command, ATTN. AMSEL-ME-NMP-~~AR~~ EM, Fort Monmouth, N.J. 07703.

**1-4. Use of Term Hertz.**

The National Bureau of Standards has officially adopted the term Hertz (Hz) for cycles per second. The chart below provides the equivalents of the unit/quantity terms and the list of approved abbreviations that will be used throughout the manual.

| *Unit/quantity* | *Old term* | *Old abbreviation* | *New term* | *New abbreviation* |
|---|---|---|---|---|
| Frequency | Cycles per second | cps | Hertz | Hz |
| $10^3$ cycles per second | Kilocycles per second | kc | Kilohertz | kHz |
| $10^6$ cycles per second | Megacycles per second | mc | Megahertz | MHz |
| $10^9$ cycles per second | Gigacycles per second | gc | Gigahertz | GHz |




TM5821-260-20-1

*Figure 1-1. Radio Set AN/ARC-115.*

## Section II. DESCRIPTION AND DATA

### 1-5. Purpose and Use

*a. Purpose.* Radio Set AN/ARC-115 (radio set) is an airborne, very high frequency (vhf), amplitude-modulated (am.), radio receiving-transmitting set which contains a multichannel, electronically tunable main receiver and transmitter, a fixed-tuned guard receiver, and has a direction finding capability when used with external equipment. The main receiver and transmitter operate on any one of 1,360 channels, spaced in 25-kHz increments in the 116.000- to 149.975-MHz frequency range. The guard receiver is fixed-tuned in the 119- to 124-MHz frequency range.

*b. Use* (fig. 1-2). The radio set, when operated in conjunction with equipment listed in paragraph 1-9, is used for receiving and transmitting clear-voice ~~or X-mode~~ communications. An additional capability for retransmission of clear-voice ~~or X-mode~~ communications allows usage of the radio set as a relay link. Use of the direction finding capability of the radio set provides an enable signal to externally located direction finding equipment. The radio set operates in conjunction with the external direction finding equipment to provide outputs to a heading indicator for a visual presentation of station direction.

### 1-6. Technical Characteristics

*a. Main Receiver.*

| | |
|---|---|
| Frequency range | 116.000 to 149.975 MHz |
| Frequency selection | Varactor tuning. |
| Number of channels | 1,360. |
| Channel spacing | 25 kHz. |
| Type of receiver | Single-conversion. |
| Type of reception | Amplitude-modulation. |
| Type of squelch | Noise operated. |

| | |
|---|---|
| Intermediate frequency. | 19.90 MHz. |
| Local oscillator control. | Digitally-tuned, indirect synthesis type. |
| Sensitivity | 3.0 microvolts for 50-mw output into 150-ohm load with 10-db signal plus noise-to-noise ratio. |
| Selectivity | 30 kHz (6 db down), 60 kHz (60 db down), and 100 kHz (80 db down). |
| Audiofrequency response. | +1 db, −2 db from 1-kHz reference across 300-Hz to 3-kHz band. |
| Antenna input impedance. | 52 ohms. |

*b. Guard Receiver*

| | |
|---|---|
| Frequency range | 119.000 to 124.000 MHz. |
| Frequency selection | Fixed-tuned, crystal-controlled. |
| Type of receiver | Single-conversion. |
| Type of reception | Amplitude-modulation. |
| Type of squelch | Noise operated. |
| Intermediate frequency. | 19.90 MHz. |
| Local oscillator control. | Crystal. |
| Sensitivity | 3.0 microvolts for 50-mw output into 150-ohm load with 10-db signal plus noise-to-noise ratio. |
| Selectivity | 30 kHz (6 db down), 60 kHz (60 db down), and 100 kHz (80 db down). |
| Audiofrequency response. | +1 db, −2 db from 1-kHz reference across 300-Hz to 3-kHz band. |
| Antenna input impedance. | 52 ohms. |

*c. Transmitter*

| | |
|---|---|
| Frequency range | 116.000 to 149.975 MHz. |
| Frequency selection | Digitally tuned, indirect synthesis type. |
| Power output | 10 watts, minimum. |
| Frequency stability | ±3.0 kHz. |
| Output check | Audio sidetone signal. |
| Antenna impedance | 52 ohms. |
| Antenna vswr | 3:1 (max). |

**d. Power Requirements**

**Normal:**

| | |
|---|---|
| Voltage | 27.5 volts dc, ±0.5, (negative ground). |
| Input power | |
| Receive operation | 21.0 watts (max). |
| Transmit operation | 85.0 watts (max). |

**Degraded:**

| | |
|---|---|
| Voltage | 24 volts dc, (negative ground). |
| Output Power | 6.0 watts (min). |

*e. Environmental.*

| | |
|---|---|
| Temperature: | |
| Normal operating. | −25°F to +131°F (−32°C to +55°C). |
| Degraded operating factor of 1/2). | −25°F to −65°F (−32°C to −54°C). |
| Storage (non-operating). | Min −65°F (−54°C) for 24 hours. Max +160°F (+74°C) for 4 hours. |
| Humidity. | 100%. |
| Acceleration. | 6 g's steady state for for 1 minute each direction in three planes. |
| Altitude. | 50,000 ft (max). |
| Orientation. | Any. |
| Heat dissipation: | |
| Normal (+28 volts): | |
| Receive operation. | 21.0 watts (max). |
| Transmit operation. | 85.0 watts (max). |

## 1-7. Components

The radio set components are listed in the following table. Refer to appendix B for the basic issue items list.

| Quantity | Item | Dimensions (in.) Height | Depth | Width | Unit weight (lb) | Figure No. |
|---|---|---|---|---|---|---|
| 1 | Radio Set AN/ARC-115 | 4¾ | 8 (max) | 5¾ | 6.50 | 1-1 |
| 1 | TM 11-5821-260-20 | | | | | 2-1 |

## 1-8. Description of Equipment

(fig. 1-1)

The radio set is a self-contained unit consisting of two major subassemblies, functionally separable

for ease of maintenance at higher maintenance categories. These two subassemblies are mechanically and electrically connected and handled as one unit at the organizational category. The front section contains the operator control panel for the radio set. All external electrical connections are made at the rear of the radio set.

## 1-9. Additional Equipment Required

(fig. 1-2)

The following additional equipment is required to operate the radio set.

*a. Communication System Control C-6533/ARC.* This control unit, or equivalent, provides audio amplification and matching of the radio set output for use with a headset. It also provides for switching between and monitoring of other radio sets when used in a system configuration.

*b. Headset-Microphone H-101A/U.* The earphone portion of this headset, or equivalent, is used to monitor the audio signal from the radio set. The microphone portion of the headset is used to provide audio information to the radio set for transmission.

*c. Power Supply.* A +27.5-volt, direct current (dc) power supply is required for radio set operation.

*d. Heading-Radio Bearing Indicator ID-1351/A and Associated Equipment.* This indicator, or equivalent, is used with associated equipment to provide a visual heading indication during operation of the radio set direction-finding capability.

*e. Relay Radio Set.* An additional radio set, such as another Radio Set AN/ARC-115, a Radio Set AN/ARC-114, a Radio Set AN/ARC-116, or equivalent, is required during operation of the radio set as a radio relay station in a radio communication system.

*f. Aircraft Am. Vhf Communication Antenna.* A 52-ohm, omnidirectional antenna is used for reception and transmission of clear-voice ~~and X-mode~~ information by the radio set.

*g. Direction Finding Equipment.* An aircraft am. direction-finding antenna and associated equipment are necessary for operation in the direction-finding mode.

## 1-10. Differences in Models

Radio Sets AN/ARC-115 SM-B-596225 and SM-B-692590 are similar in purpose, operation and appearance, and are interchangeable provided that the aircraft does not have a dagger pin mounting capability. If such a dagger pin mounting capability exists, only Radio Set AN/ARC-115 SM-B-692590 may be used. The differences between the two models of the radio set are:

| Subassembly | Radio Set AN/ARC-115 SM-B-596225 | Radio Set AN/ARC-115 SM-B-692590 |
|---|---|---|
| Front Radio Set Subassembly A1 | The front radio set subassembly A1 for this radio set is of one configuration:SM-B-618024. | The front radio set subassembly A1 for this radio set is of one configuration: SM-B-692592. The differences between these subassemblies are internal in nature and are not evident by visual inspection of the radio set. |

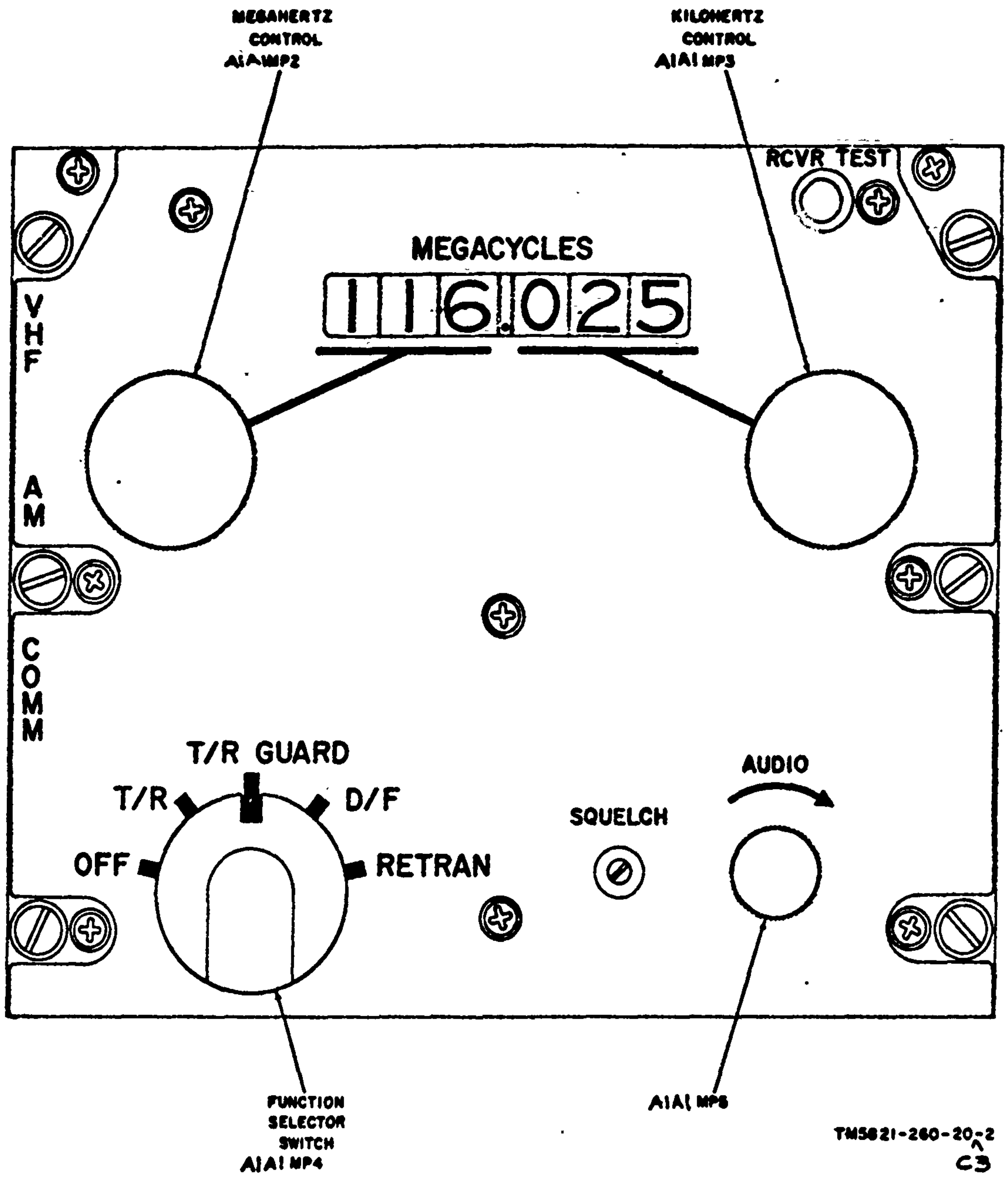



*Figure 3-1. Radio set front panel.*

## CHECK-OFF LIST FOR BENCH TEST

Equipment AN/ARC-115( ) Serial No. ______

| APPLICABLE PARAGRAPH | TESTS | MINIMUM STANDARD | TEST DATA | REMARKS |
|---|---|---|---|---|
| | | | Check Compliance | |
| 4.2.4.2 | Transmitter | | (✓) | |
| 4.2.4.2.1 | Sidetone and Power Output | Sidetone present at each frequency | ( ) | |
| | | Power Output: | | |
| | | 9 watts min at 116.050 MHz | ____ | |
| | | 9 watts min at 124.675 MHz | ____ | |
| | | 9 watts min at 132.150 MHz | ____ | |
| | | 9 watts min at 138.375 MHz | ____ | |
| | | 9 watts min at 149.950 MHz | ____ | |
| 4.2.4.2.2 | Frequency | 149.950 MHz ± 3 kHz | ____ | |
| | | 138.375 MHz ± 3 kHz | ____ | |

Figure 1A. Check-off List (Sheet 1 of 4 sheets).

## CHECK-OFF LIST FOR BENCH TEST (CONT)

Equipment AN/ARC-115( ) Serial No. ______

| APPLICABLE PARAGRAPH | TESTS | MINIMUM STANDARD | TEST DATA | REMARKS |
|---|---|---|---|---|
| | | | Check Compliance(✓) | |
| 4.2.4.2.2 (Cont) | | 132.150 MHz ± 3 kHz | ____ | |
| | | 124.675 MHz ±3 kHz | ____ | |
| | | 116.050 MHz ± 3 kHz | ____ | |
| 4.2.4.2.3 | RETRAN | Sidetone present | ( ) | |
| | | Power Output: | | |
| | | 9 watts min | ____ | |
| 4.2.4.2.4 | Modulation | Modulation: | | |
| | | 70 to 100% at 149.950 MHz | ( ) | |
| | | 70 to 100% at 138.375 MHz | ( ) | |
| | | 70 to 100% at 132.150 MHz | ( ) | |
| | | 70 to 100% at 124.675 MHz | ( ) | |

Figure 1A. Check-off List (Sheet 2 of 4 sheets).

CHECK-OFF LIST FOR BENCH TEST (CONT)

Equipment AN/ARC-115( ) Serial No. ________

| APPLICABLE PARAGRAPH | TESTS | MINIMUM STANDARD | TEST DATA | REMARKS |
|---|---|---|---|---|
| | | | Check Compliance (✓) | |
| 4.2.4.2.4 (Cont) | | 70 to 100% at 116.050 MHz | ( ) | |
| 4.2.4.3 | Receiver | | | |
| 4.2.4.3.1 | Sensitivity and Receiver Self Test | Tone in headset at each frequency | | |
| | | $\frac{S+N}{N}$ = 10 db min at 116.050 MHz | ____ | |
| | | $\frac{S+N}{N}$ = 10 db min at 126.00 MHz | ( ) ____ | |
| | | $\frac{S+N}{N}$ = 10 db min at 132.150 MHz | ( ) ____ | |
| | | $\frac{S+N}{N}$ = 10 db min at 138.375 MHz | ( ) ____ | |
| | | $\frac{S+N}{N}$ = 10 db min at 149.950 MHz | ( ) ____ | |

Figure 1A. Check-off List (Sheet 3 of 4 sheets).

## CHECK-OFF LIST FOR BENCH TEST (CONT)

Equipment AN/ARC-115( ) Serial No. ______

| APPLICABLE PARAGRAPH | TESTS | MINIMUM STANDARD | TEST DATA | REMARKS |
|---|---|---|---|---|
| | | | Check Compliance (✓) | |
| 4.2.4.3.2 | T/R GUARD Sensitivity | $\frac{S+N}{N}$ = 10 db min | ____ | |
| 4.2.4.3.3 | Squelch Re-adjustment | Main receiver squelch operates properly | ( ) | |
| | | Guard receiver squelch operates properly | ( ) | |
| 4.2.4.3.4 | RETRAN | Receiver Audio: | | |
| | | 2.75 v rms nominal | ____ | |
| | | MK-994/AR CONTROL/SIGNAL lamp illuminated | ( ) | |

Figure 1A. Check-off List (Sheet 4 of 4 sheets).